Dialysis associated Hypotension

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- Goals
  - Understand the potential risks and benefits of sodium modeling, ultrafiltration modeling, and alterations of dialysate calcium and temperature levels in attempting to minimize dialysis associated hypotension

Finangle's First Law

If an experiment works,
something has gone wrong

Finagle's Second Law

No matter what the experiment's results, there will always be someone eager to :

(a) misinterpret it

(b) fake it, or

(c) believe it supports his own pet theory

Commonly used interventions

- Dialysate temperature adjustments
- Dialysate calcium adjustments
- Sodium modeling
- UF modeling

Temperature adjustments

- Theory
  - cooling dialysate results in less hemodynamic instability
- Practice
  - how does it work?
  - How significant of an effect on bp?
  - Is the effect linear?
  - What are the potential side effects?
  - Are there patients in whom it is contraindicated?

Temperature Adjustment- the studies

- Epidemiology of symptomatic hypotension in hemodialysis: Is cool dialysate beneficial for all patients? AJN 1990
- Effects of cooler temperature dialysate on hemodynamic stability in “problem” dialysis patients. KI 1993
- Effect of dialysate temperature on central hemodynamics and urea kinetics. KI 1995

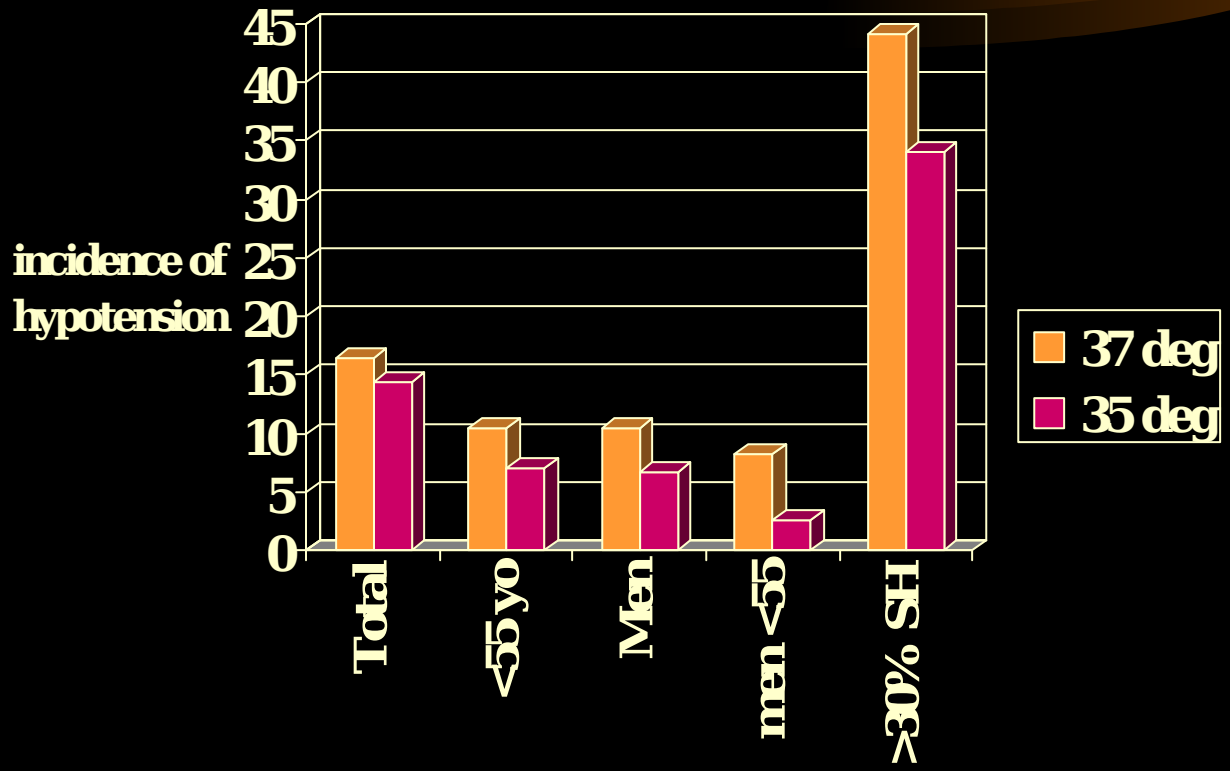
Is Cool Dialysate Beneficial for all patients? AJN 1990

- Prospective study in 60 non-diabetic patients
- 6 months at 37 degrees C, then 6 months at 35 degrees C
- total of 7700 sessions
- Assess characteristics of most affected patients

Is Cool Dialysate Beneficial for all patients?

- Results
  - incidence of symptomatic hypotension correlated with:
    - sex- higher in females
    - age greater than 55 years
    - cardiovascular disease
    - intradialytic weight gains

Is Cool Dialysate Beneficial for all patients?



Is Cool Dialysate Beneficial for all patients?

- Side effects
  - less than 2% of sessions and never required interruption of treatment
  - larger interdialytic weight gains
    - 0.4 kg ($p<0.0001$)

Is Cool Dialysate Beneficial for all patients?

- Other
  - no effect on cramps which accounted for 62% of sx other than hypotension

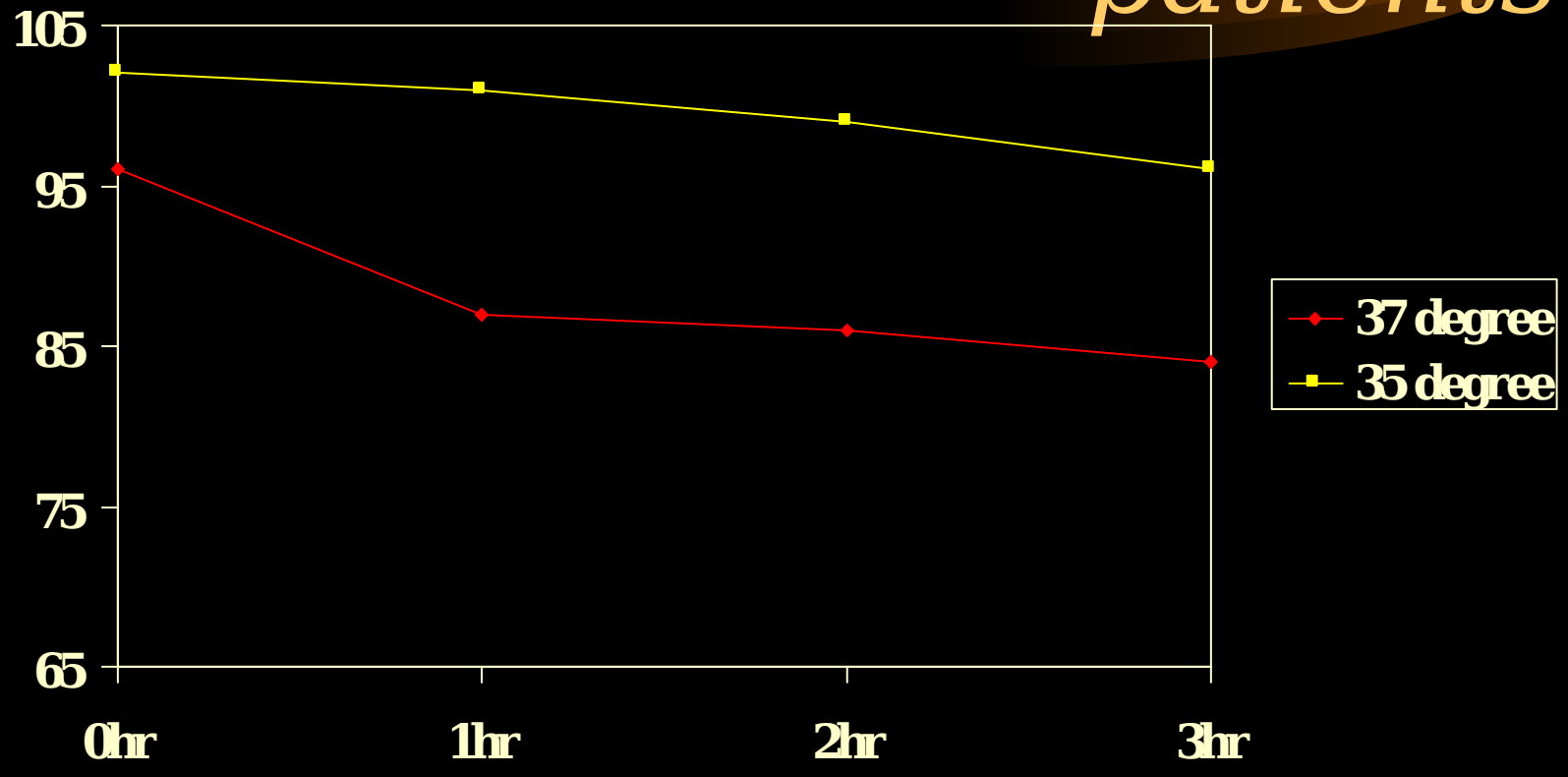
Cooler temperature dialysate in "problem" patients

- Double blinded cross-over protocol-- 6 hypotension prone patients and 6 with h/o large IDWG
- One tx at 37 degrees C and one a week later at 35 degrees C
- Measured side effects, recumbent bp, standing bp, oral temperature, regional blood flow via plethysmography, episodes of sx hypotension, and plasma norepi levels

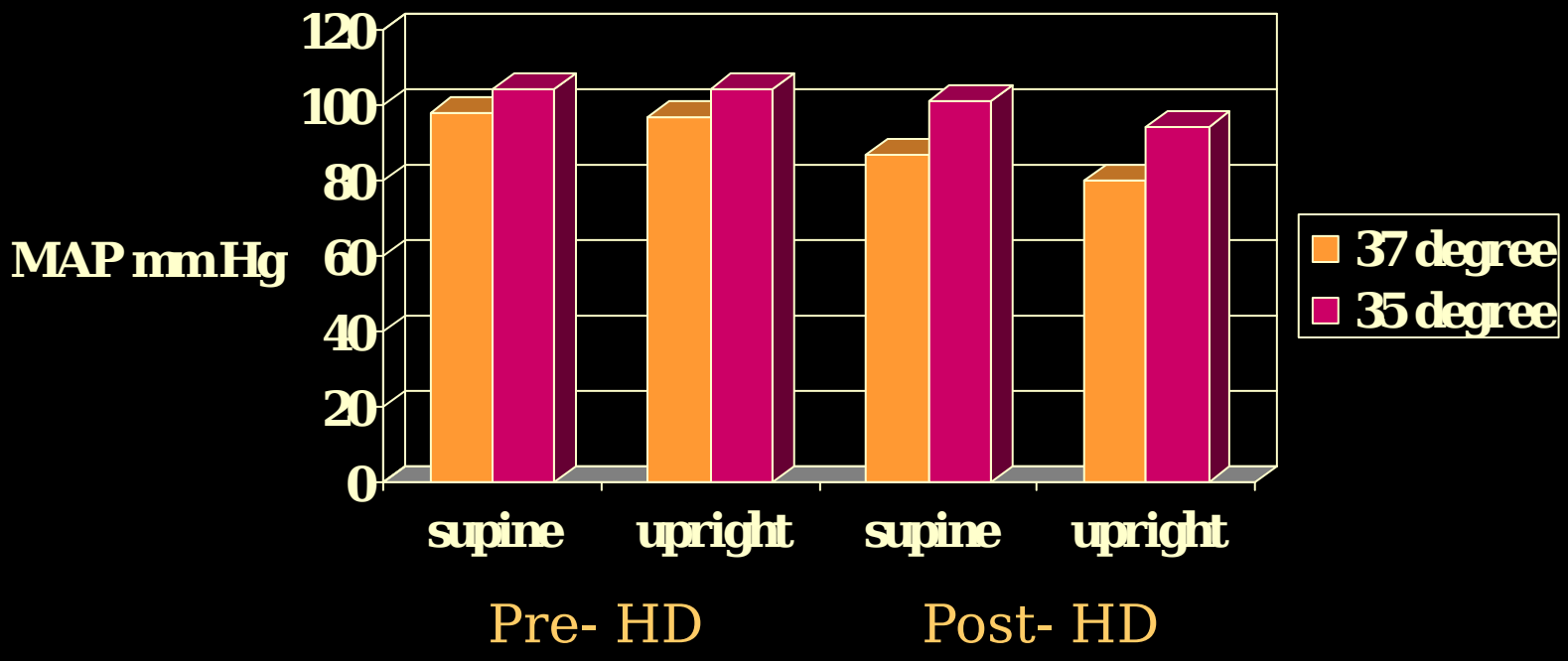
Cooler temperature dialysate in "problem" patients

- Results-
  - Body temperature
    - 35 degrees C-- body temp decreased .42 degrees C
    - 37 degrees C-- body temp increased .11 degrees C
  - Blood pressure
    - 35 degrees C-- decreased mean of 6mm/Hg
    - 37 degrees C-- decreased mean of 12mm/Hg

Cooler temperature dialysate in "problem" patients



Cooler temperature dialysate in "problem" patients

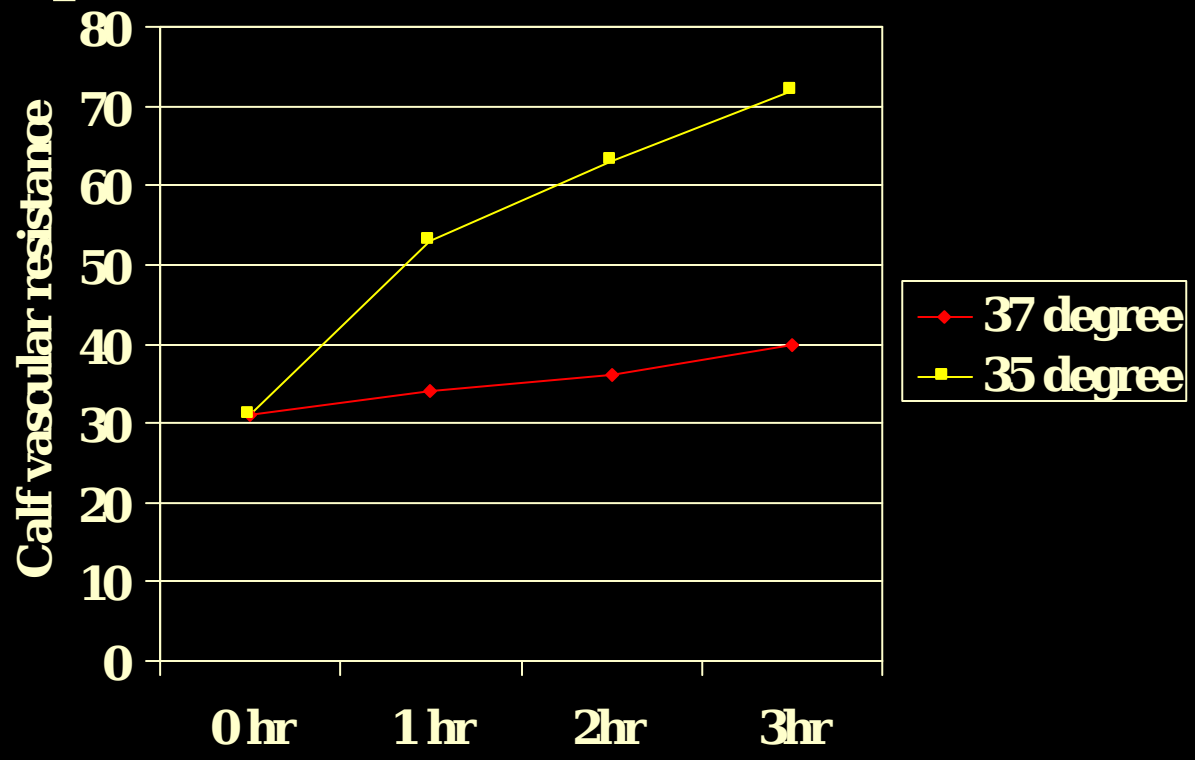


Cooler temperature dialysate in "problem" patients

- 18 episodes of sx hypotension
  - all 18 in the 37 degree group

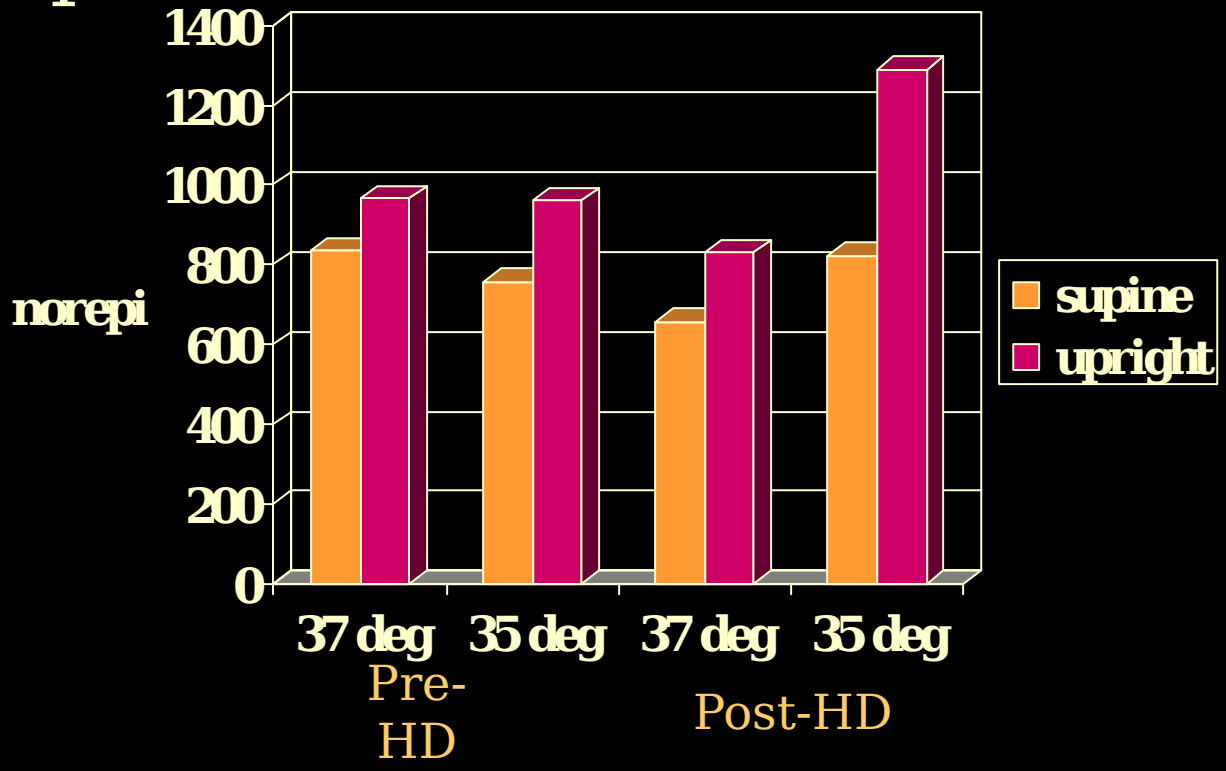
Cooler temperature dialysate in "problem" patients

- Effect on calf blood flow and peripheral vascular resistance



Cooler temperature dialysate in "problem" patients

- Effect on supine and upright norepi levels



Cooler temperature dialysate in "problem" patients

- Side Effects
  - no reported episodes of chills
- Theoretical
  - excessive vasoconstriction and ischemia in patients with marginal peripheral circulation

Cooler temperature dialysate in "problem" patients

- Overall
  - efferent sympathetic outflow mirrored the changes in peripheral vascular resistance
  - cold pressor test known to increase sympathetic outflow
  - possible the total body cooling of 0.3 to 0.5 degrees C causes a similar reaction

Dialysate temperature and symptomatic hypotension

- Take home points
  - well tolerated (<2% sx of chills)
  - magnitude of effect approx 7mm Hg
  - most effective for patients with frequent episodes of hypotension
  - mediated by increased norepi
  - no effect on cramping

Wyszowki's Law

No experiment is reproducible

Dialysate Calcium Adjustments

- Theory
  - increasing dialysate calcium results in less hemodynamic instability
- Practice
  - How does it work?
  - How significant is the effect on bp? Is it additive with Na/temp modeling?
  - Does the initial level of Ca make a difference?
  - What are the side effects?
  - Are there patients in whom it is contraindicated?

Dialysate Calcium Adjustments- the studies

- The Effect of Dialysate Calcium levels on Blood Pressure during Hemodialysis. AJKD 1986
- Blood Pressure Response to Changes in Serum Ionized Calcium During Hemodialysis. AIM 1986

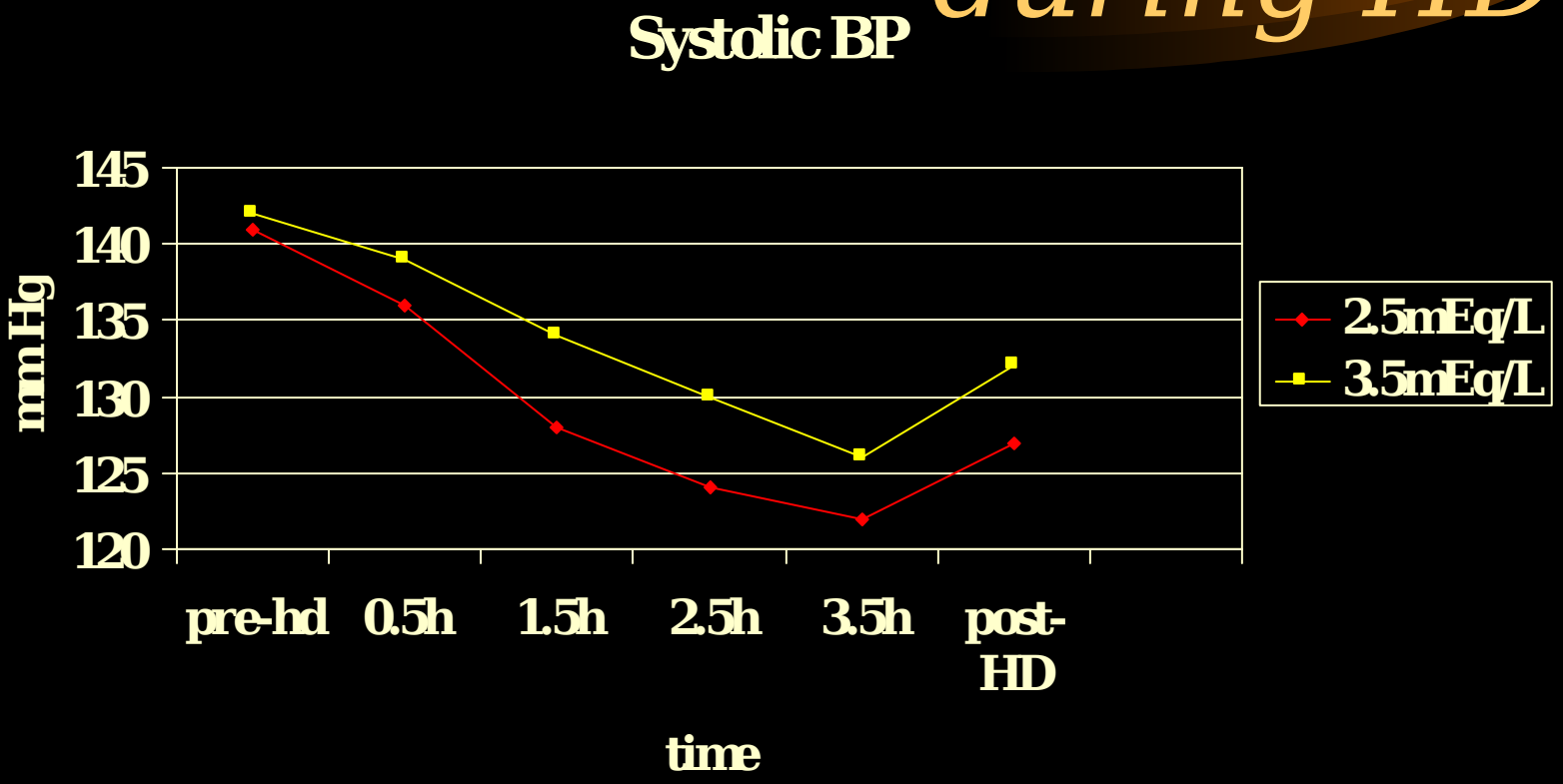
Effect of Dialysate Calcium Levels on BP during HD

- Double-blind prospective study
- 20 patients / 240 treatments
- alternated dialysis with 2.5 mEq/L and 3.5 mEq/L of calcium
- measured mean bp at 0, .5, 1.5, 2.5, 3.5 hours, and post-HD, volume of saline given, pre/post serum calcium, episodes of sx hypotension/cramping
- Sub-group analysis of patient's with frequent hypotension

Effect of Dialysate Calcium Levels on BP during HD

- Results
  - Ca of 2.5 resulted in a statistically significant reduction in mean BP during HD

Effect of Dialysate Calcium Levels on BP during HD



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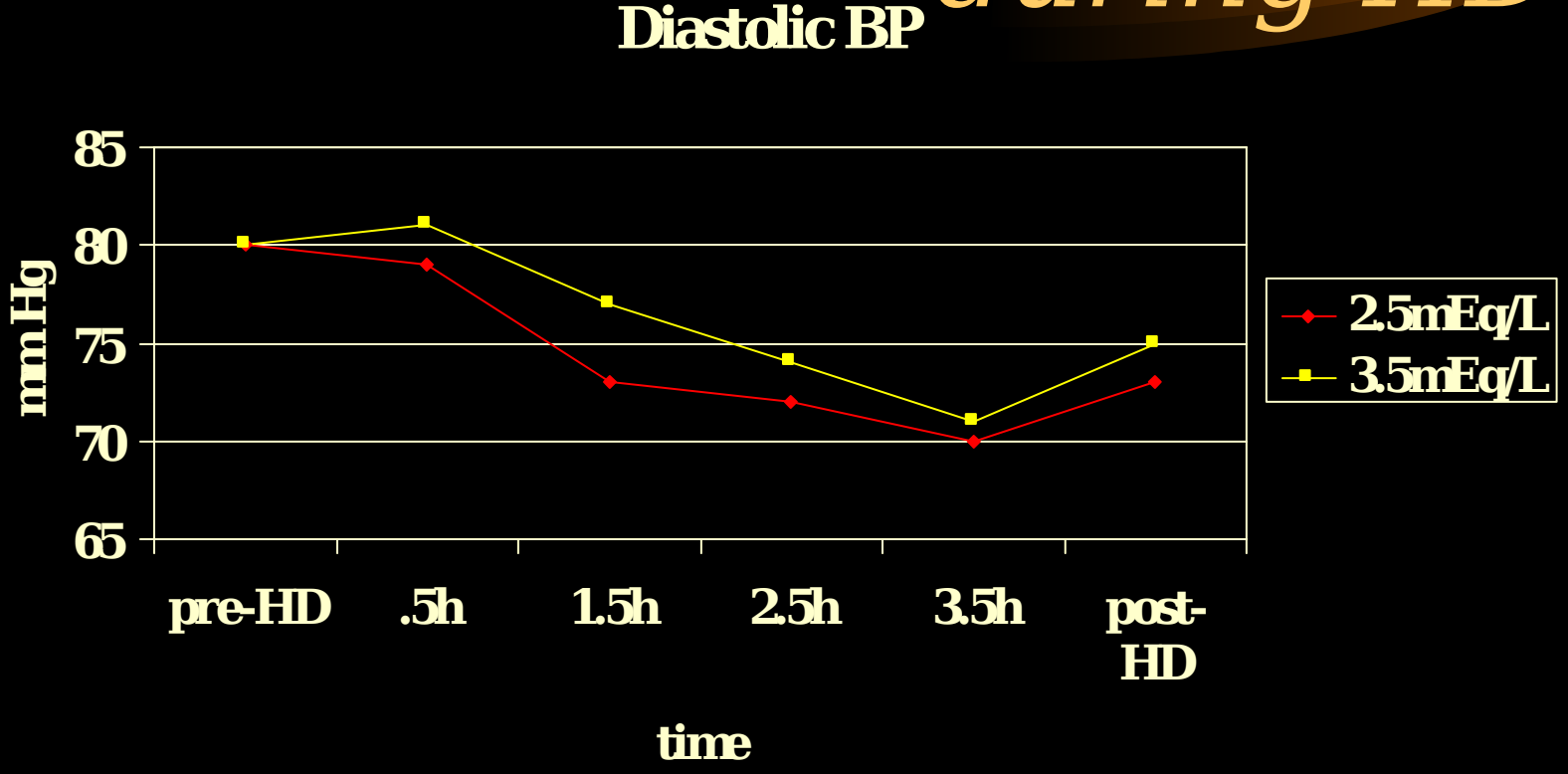
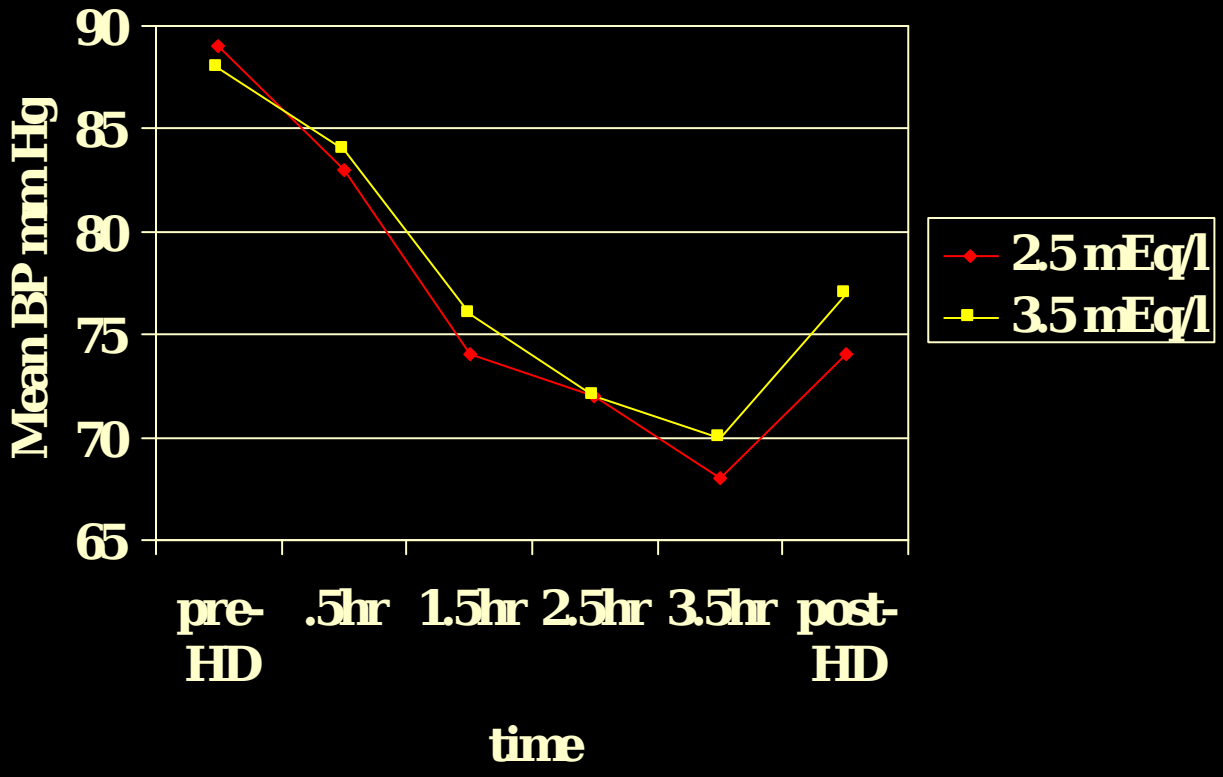


Effect of Dialysate Calcium Levels on BP during HD

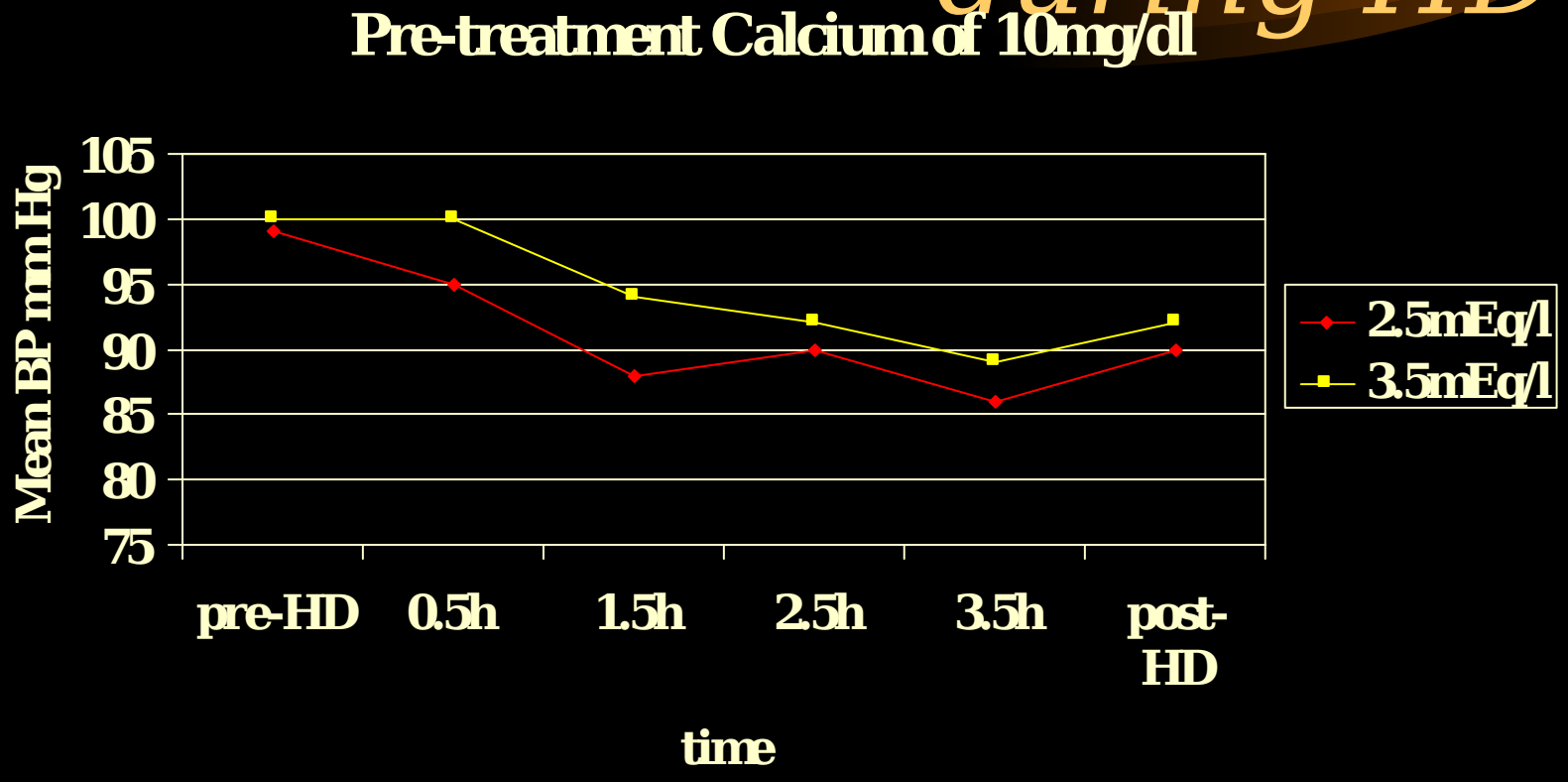
- Results (low ca vs. high ca)
  - episodes of symptomatic hypotension
    - .48 vs .42 episodes/dialysis p=.54
  - saline requirements
    - 88.1 vs. 72.2 mL/dialysis p=.31
  - muscle cramping
    - .16 vs. .10 episodes/dialysis p=.25

Effect of Dialysate Calcium Levels on BP during HD

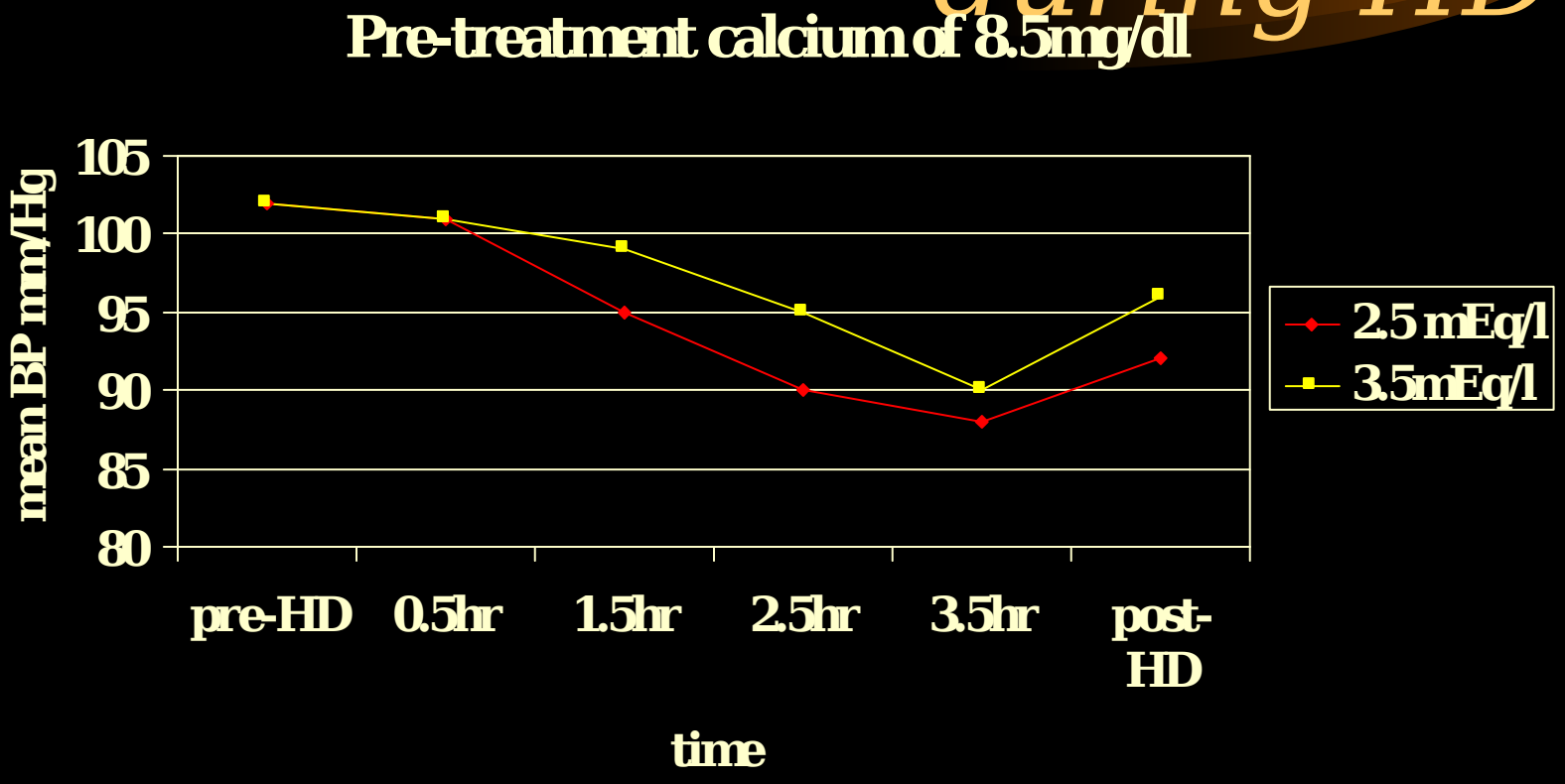
- Results in high risk sub-group



Effect of Dialysate Calcium Levels on BP during HD



Effect of Dialysate Calcium Levels on BP during HD



Effect of Dialysate Calcium Levels on BP during HD

- Side effects
  - not commented upon
- Mechanism
  - not commented upon

BP Responses to changes in Serum Ionized Ca During HD

- Prospective randomized, double-blind crossover trial
- 12 patients
- 3 tx with Ca 5.5mg/dL and 3 at 7.5mg/dL
- measured serial bp’s and ionized calcium

BP Responses to changes in Serum Ionized Ca During HD

- Results
  - Less decrease in sbp
    - -18 vs. -9 mm/Hg (p<0.03)
  - Less decrease in dbp
    - -8 vs. -2 mm/Hg (p<0.01)
  - Ionized Ca
    - .55 vs. .91 mg/dL (p<.0001)

BP Responses to changes in Serum Ionized Ca During HD

- Mechanism
  - first noted during inadvertent dialysis against high bath
  - infusion experimentally increases PVR
  - increased cardiac output
  - increased epi and norepi levels

BP Responses to changes in Serum Ionized Ca During HD

- Side Effects
  - maximum serum Ca obtained was 11.6mg/dl
  - no sx hypercalcemia during study

Calcium and hypotension

- Overall
  - responsiveness not assoc with specific patient factors
  - results in a statistically significant blunting of hypotensive response
  - probably works via a mechanism independent of na and temperature modeling
  - no significant reported side effects

Fett's Law

Never replicate a successful experiment

Sodium Modeling

- Theory
  - maintains intravascular volume at the start of HD when osmotic shifts the greatest
- Practice
  - How does it work?
  - How significant of an effect on bp?
  - What is the best profile?
  - What are the observed side effects?

Sodium Modeling

- A Double-Blind Evaluation of Sodium Gradient Hemodialysis. AJN 1985
- Sodium Modeling Ameliorates Intradialytic and Interdialytic Symptoms in Young Hemodialysis Patients. JASN 1993

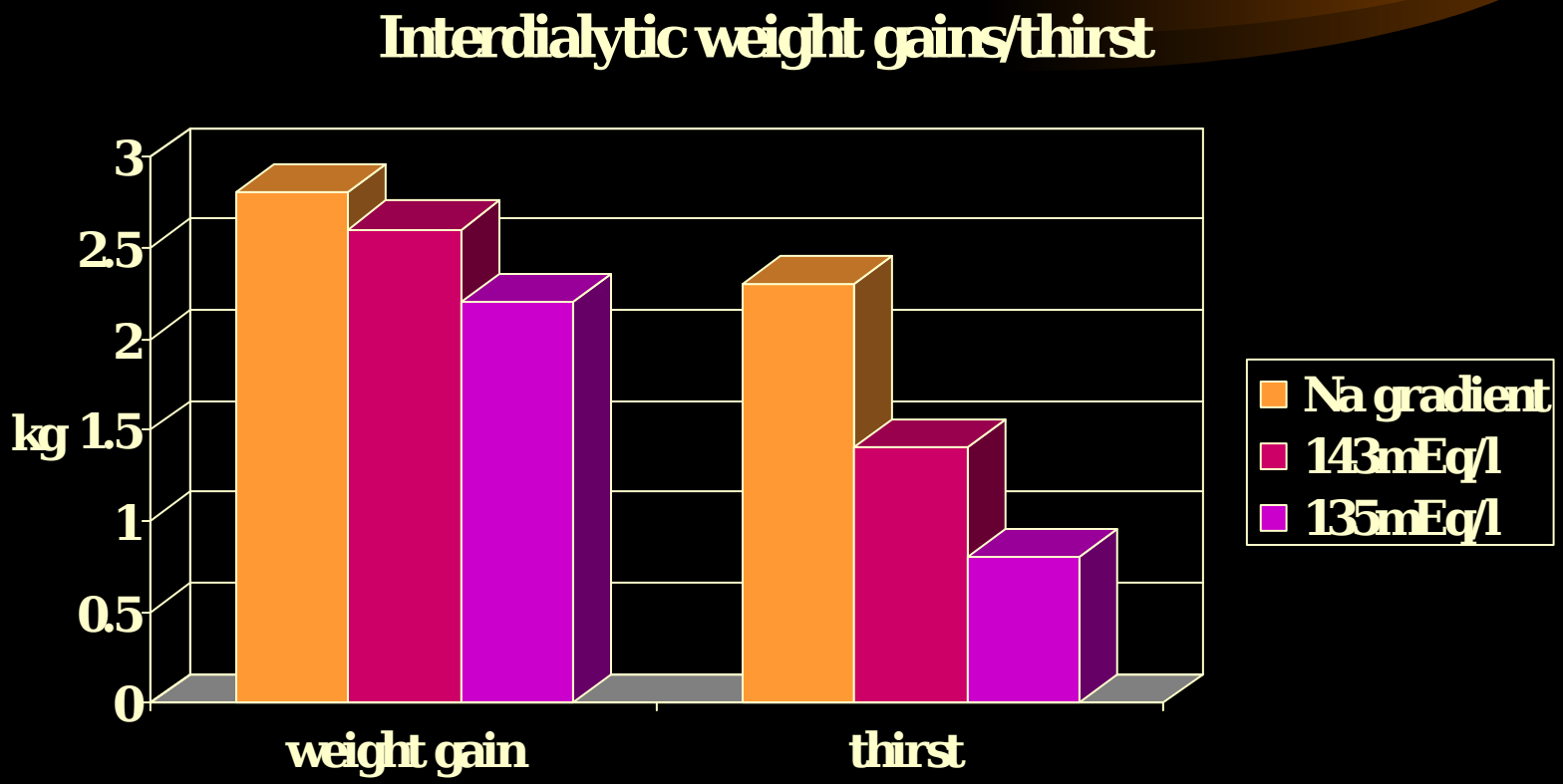
Evaluation of Sodium Gradient Hemodialysis

- Double-blind crossover trial
- 7 chronic HD patient-- three 4 week treatment periods
  - period one - na 135
  - period two- na 143
  - period three- na 160 to 133

Evaluation of Sodium Gradient Hemodialysis

- Measurements
  - intra-dialytic weight gains
  - thirst
  - hypotension and cramping during HD
  - pre-HD bp
  - mid-HD bp

Evaluation of Sodium Gradient Hemodialysis



Evaluation of Sodium Gradient Hemodialysis

- 40/189 dialyses required intervention
  - Na gradient- 14
  - 135mEq/l - 13
  - 145mEq/l - 13

Evaluation of Sodium Gradient Hemodialysis

- Time of hypotensive episodes
  - 1st hour- none
  - 2nd hour- 2
  - 3rd hour- 7
  - 4th hour- 31

Evaluation of Sodium Gradient Hemodialysis

- Pre-dialysis blood pressures
  - unchanged
- Mid-point blood pressures
  - higher in high Na groups
    - approx 5mm Hg
- Pre-dialysis sodium levels
  - 137.7 (HD at 135) vs. 139.7 (HD with Na grad)

Evaluation of Sodium Gradient Hemodialysis

- Authors opinions
  - increased Na resulted in increased thirst and intradialytic weight gain
  - did not result in intradialytic hypertension
  - no difference in hypotensive episodes
  - trend toward decreased cramps

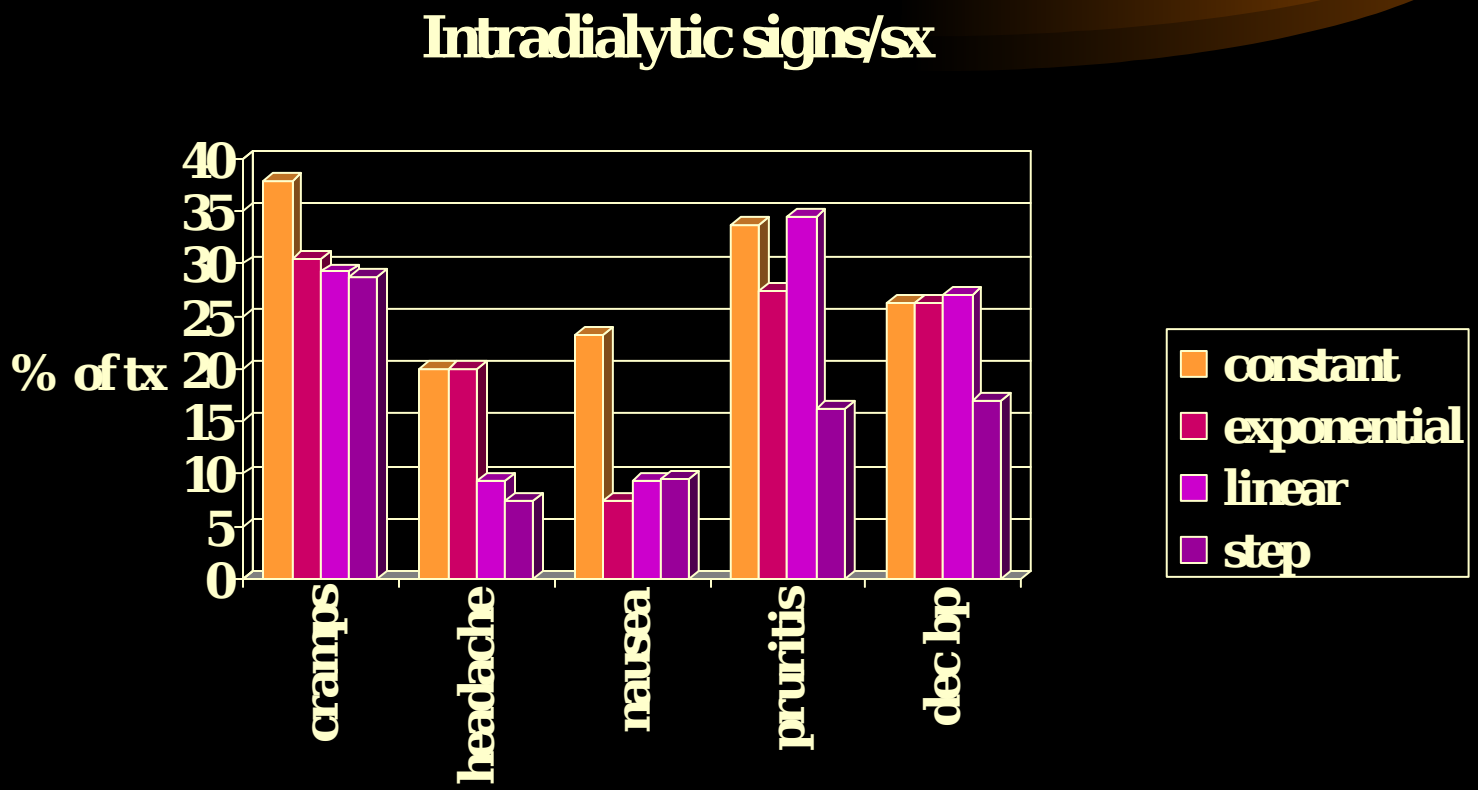
Sodium Modeling in Young HD patients

- 16 patients/ 8 week trial
- 8 weeks split into:
  - 2 weeks- linear
  - 2 weeks- exponential
  - 2 weeks- step
  - 2 weeks- 138 mEq/l
- 2 weeks blocks performed in random order

Sodium Modeling in Young HD patients

- Evaluated
  - symptoms during the treatment, and symptoms in the 12 hours after
  - interdialytic weight gain
  - pre/post treatment weights
  - pre/post blood pressure

Sodium Modeling in Young HD patients



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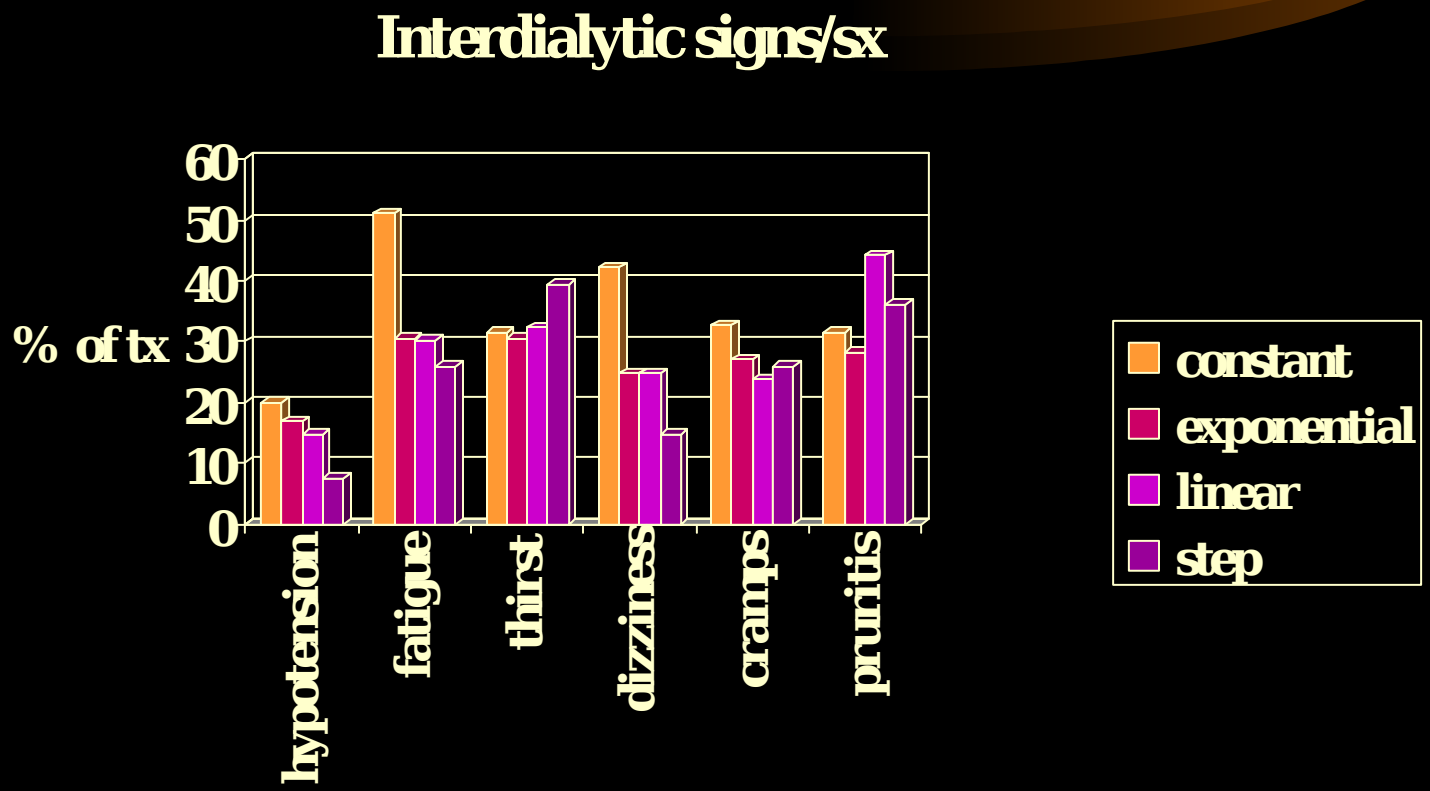

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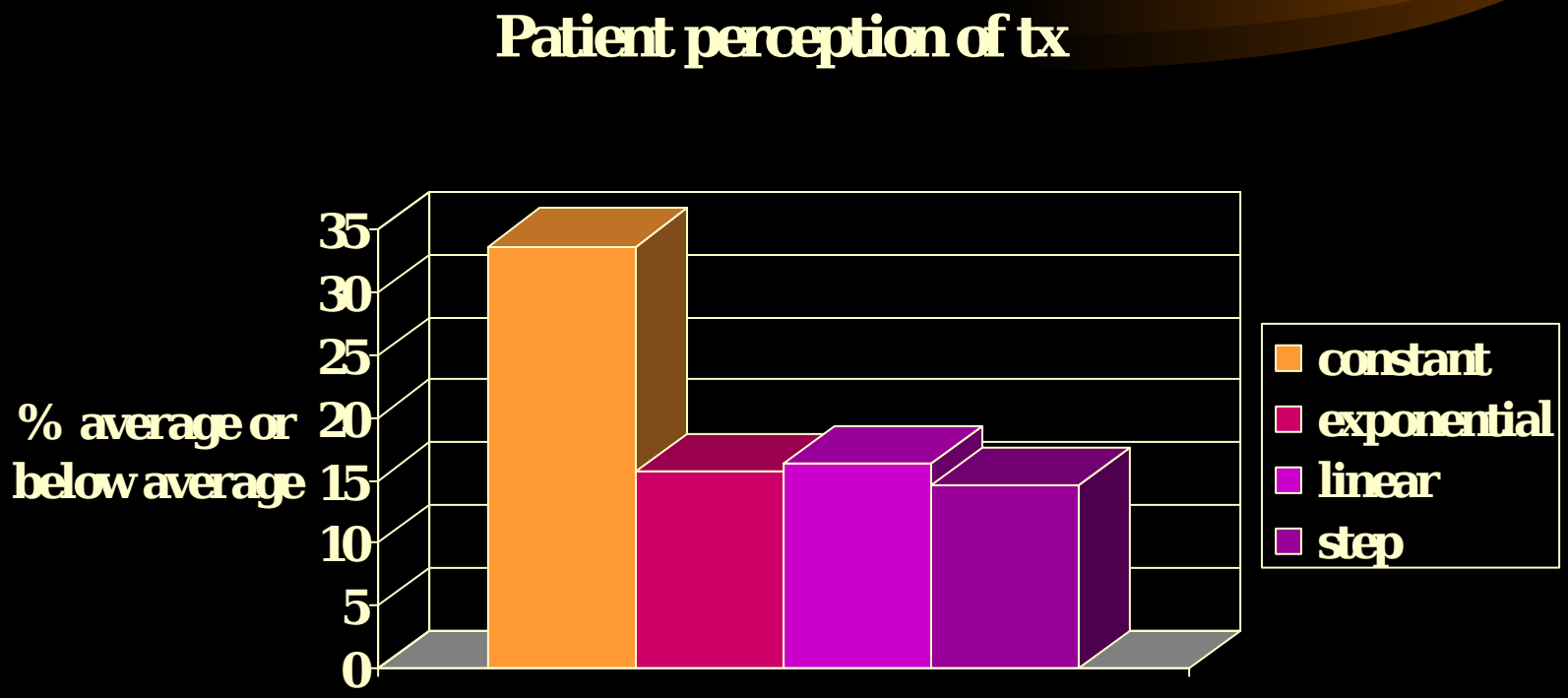
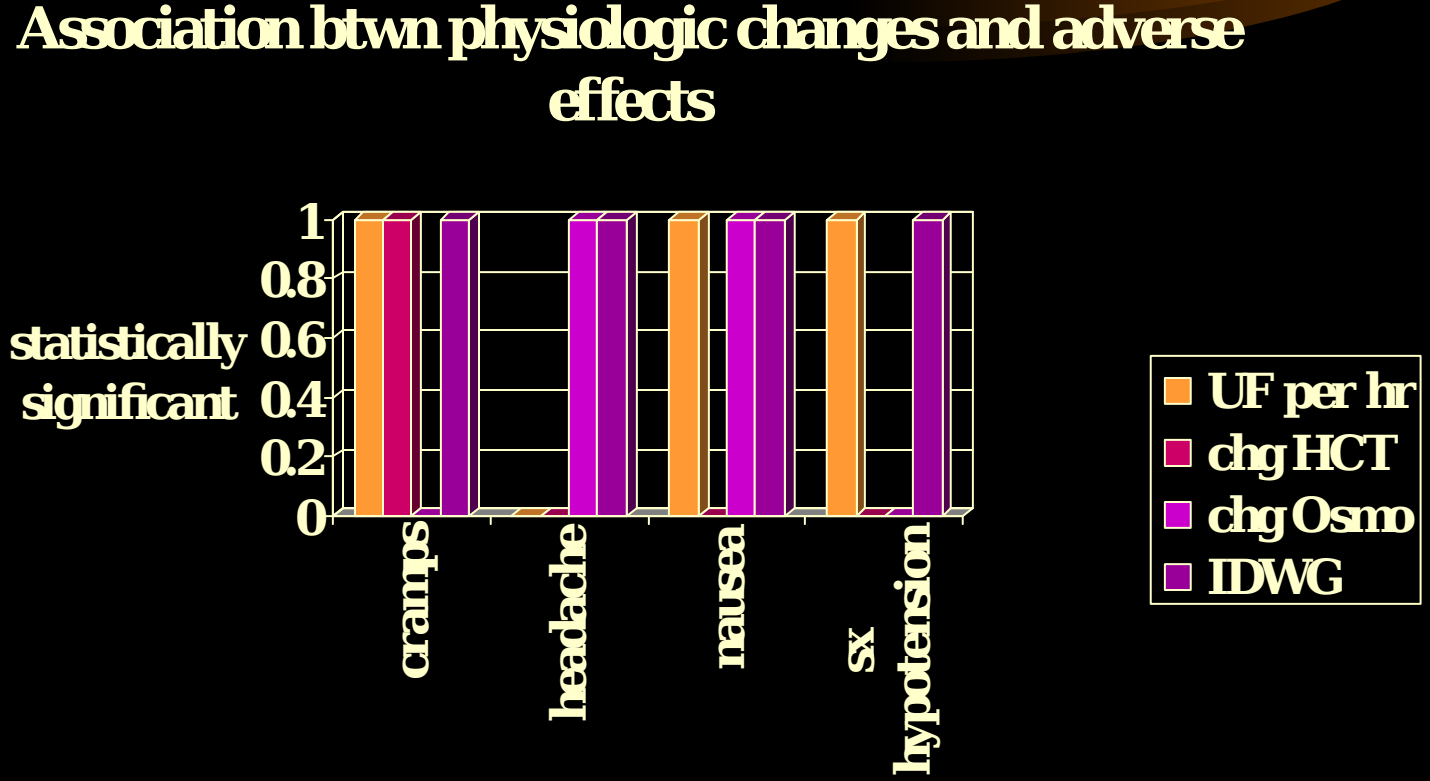


Sodium Modeling in Young HD patients



Sodium Modeling in Young HD patients

- Overall
  - no increase in interdialytic thirst, IDWG, or hypertension

Sodium Modeling in Young HD patients

- Particular Sodium program benefits
  - Linear
    - only program which significantly decreased interdialytic cramps
  - Step
    - best at preventing post-dialysis hypotension
    - better at preventing HA (along with linear)

Sequential Sodium Method

- Limit UF to first three hours of dialysis whenever a sodium gradient method is used
- Osmotic contraction of the blood volume during the last hour would then not be aggravated by continued ultrafiltration
- Dumler, TASAIO 1979 25: 351-353

Murphy's Law of Research

When working toward the solution of a problem, it always helps if you know the answer

Sequential Ultrafiltration

- Theory
  - performing isolated ultrafiltration at the start of HD allows for greater total fluid removal with less hemodynamic instability
- Practice
  - how does it work?
  - What is the impact on dialysis efficiency?
  - Side effects and contraindications?

Sequential Ultrafiltration

- Hemodynamic changed during sequential ultrafiltration and dialysis. KI 1979
- Hemodynamic changes induced by regular hemodialysis and sequential ultrafiltration hemodialysis: A comparative study. KI 1980

Sequential HD and ultrafiltration

- 7 HD patients (one with bilateral nephrectomy)
- measured serial bps, weights, heart rate, cardiac output, peripheral vascular resistance, PRA

Sequential HD and ultrafiltration

- Results
  - Isolated UF
    - decreased cardiac output 2nd decreased stroke volume
    - increased peripheral vascular resistance
      - increased PRA
      - nephrectomized patient with inc pvr
    - stable bp

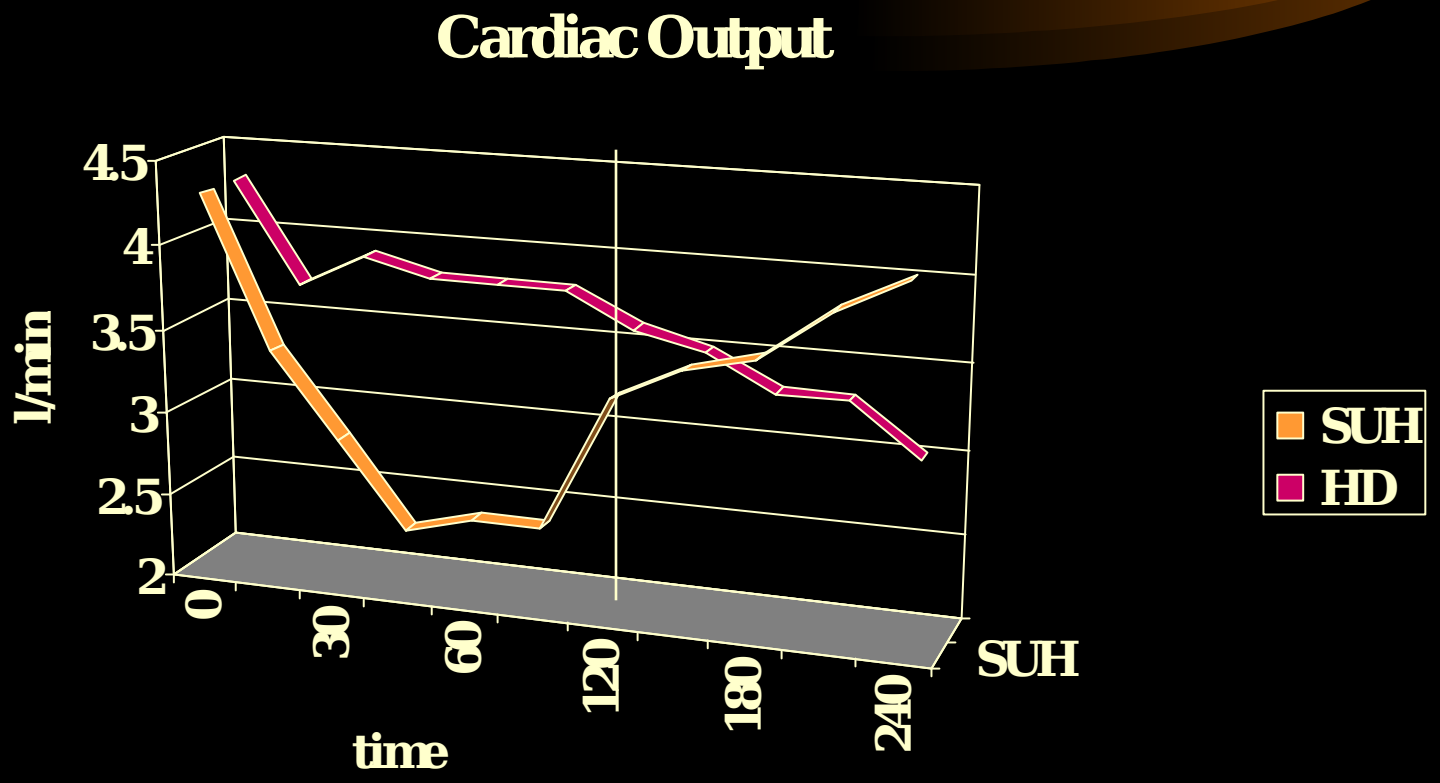
Sequential HD and ultrafiltration

- Results
  - Dialysis
    - significant decrease in PVR
      - decreased PRA
    - increase in HR
    - increase in CO

Comparative Study of HD and Sequential UF HD

- 10 patients
- Two HD sessions each-- one with SUH and the other routine HD
- All patients had a femoral Swan placed before first HD session and left in place X 72 hours
- Measured-- bp, plasma volume, full Swan parameters

Comparative Study of HD and Sequential UF HD



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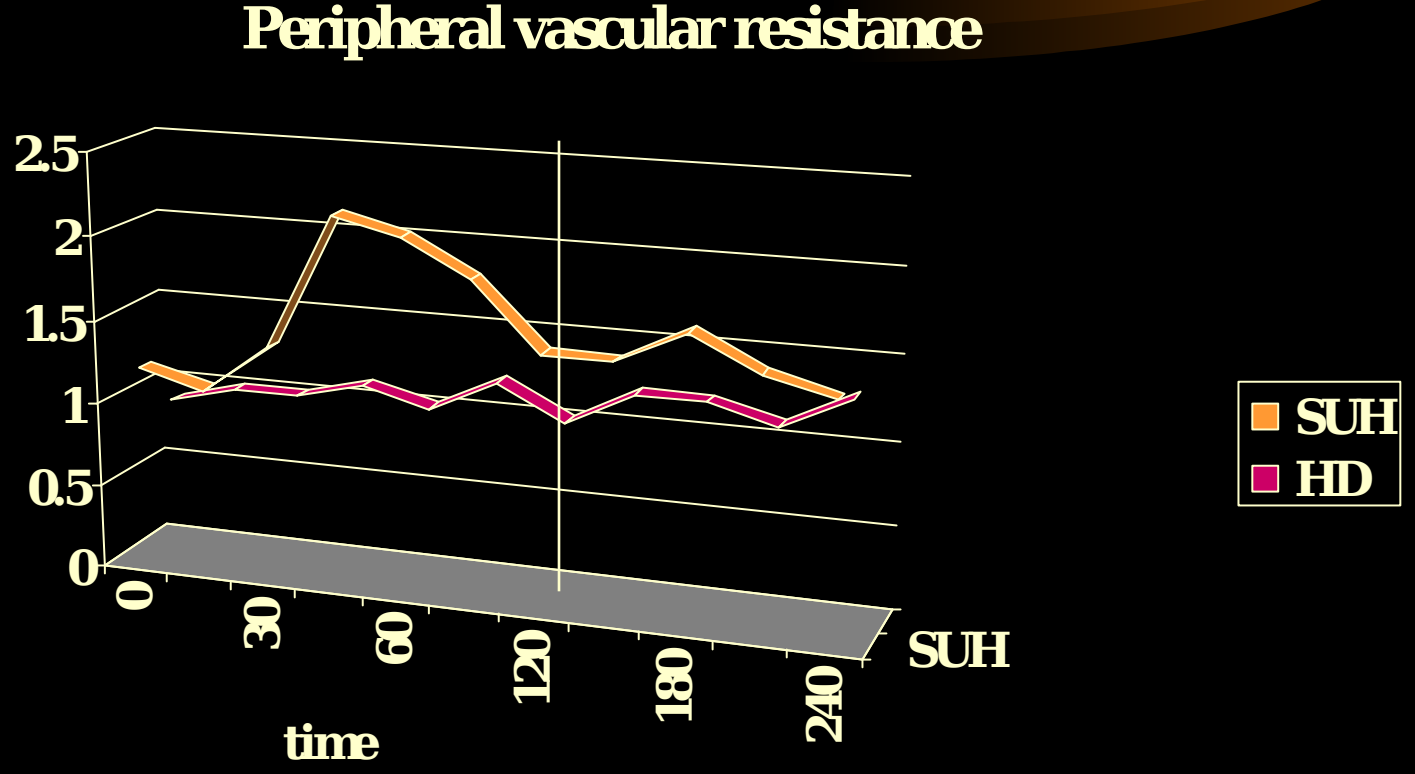

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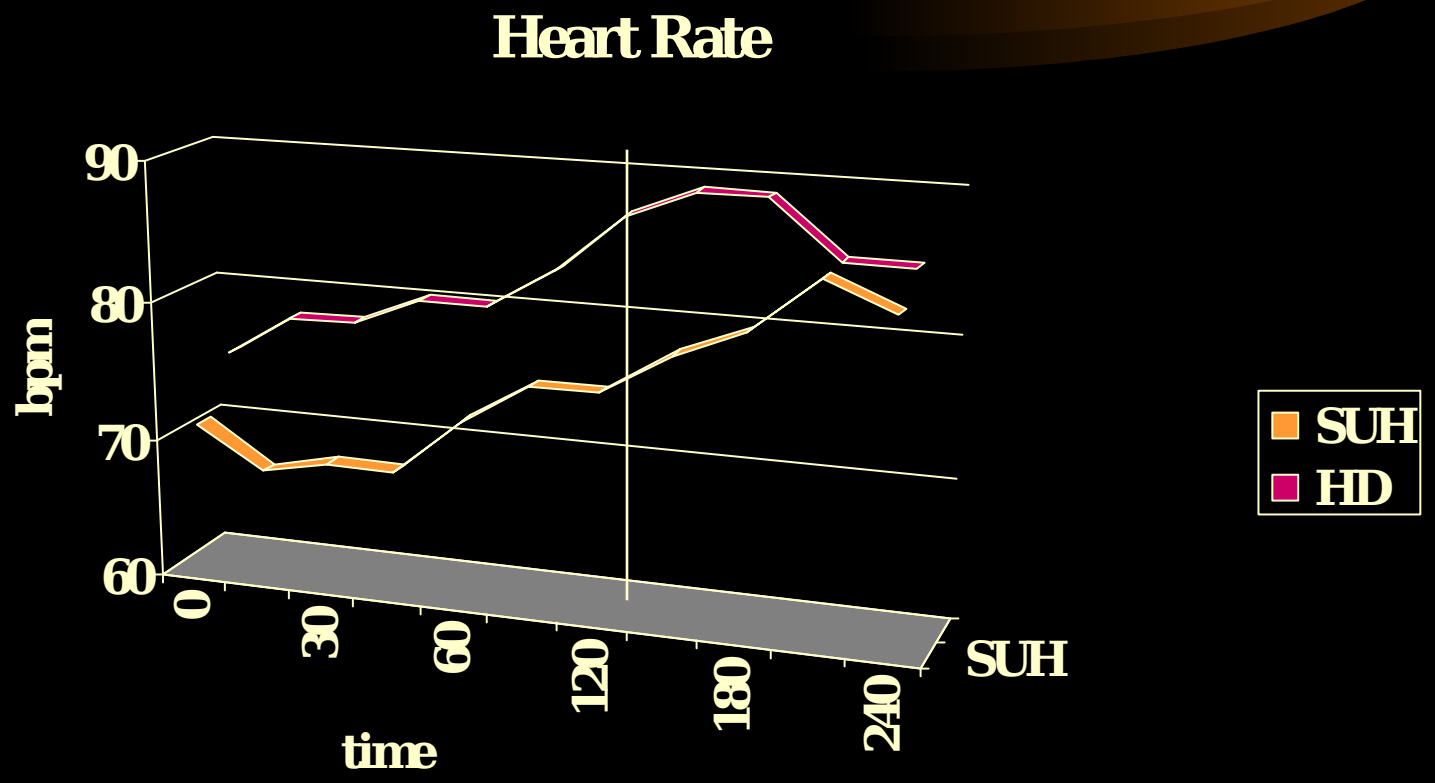

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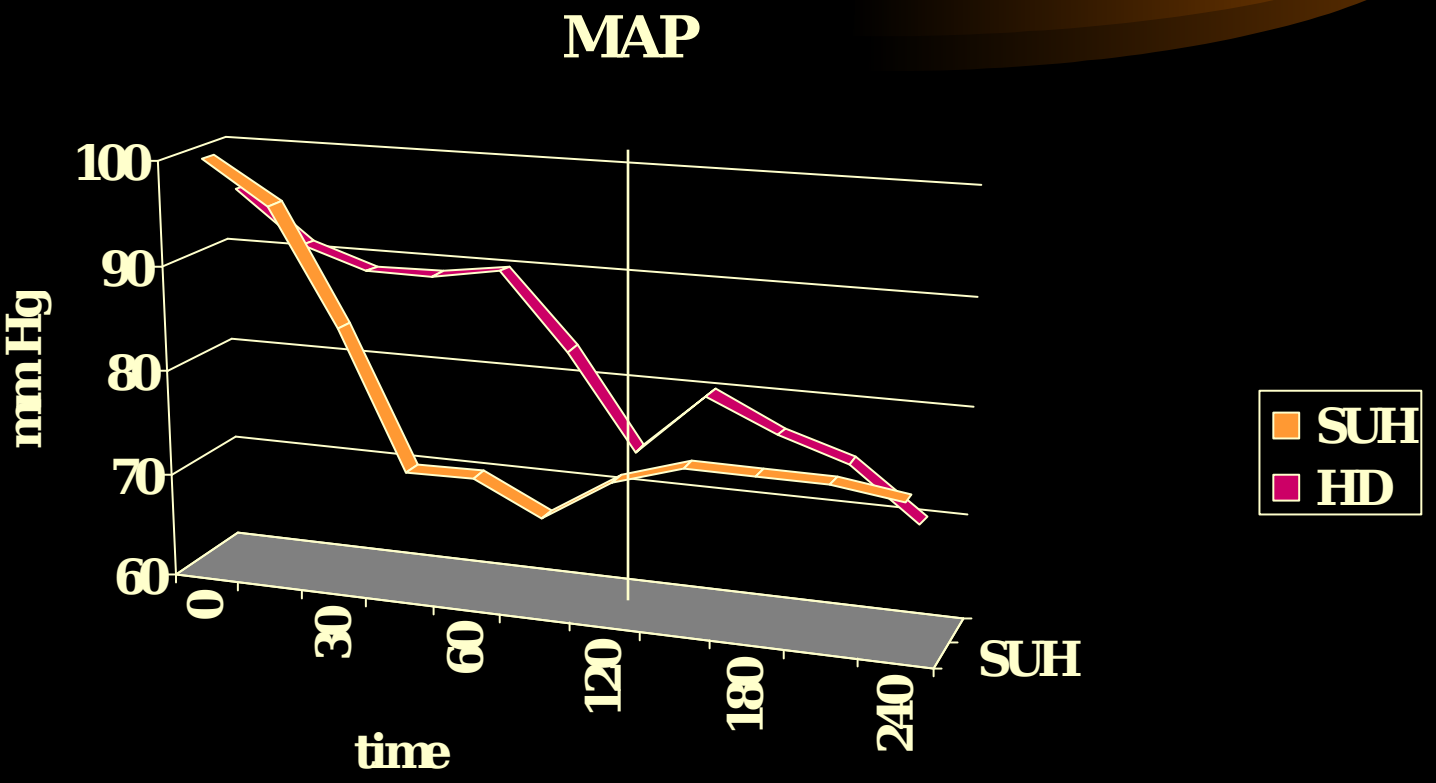

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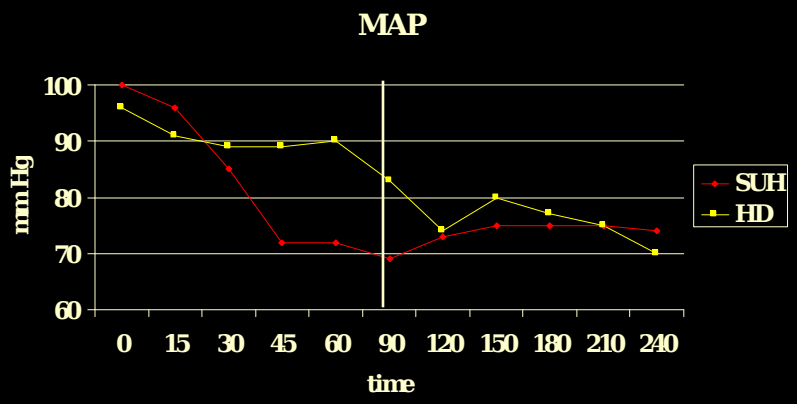

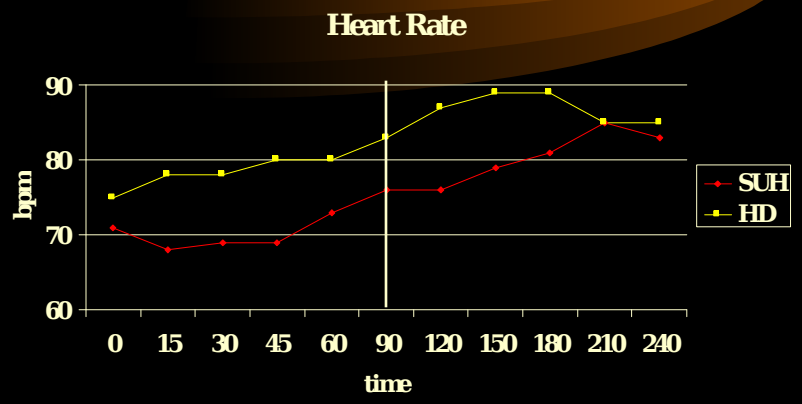

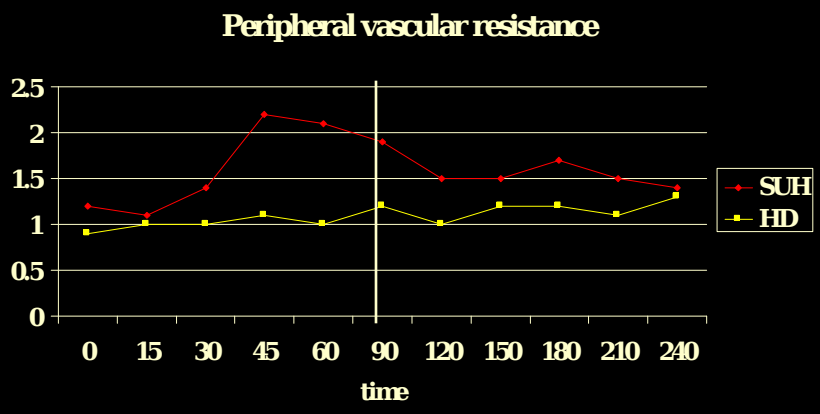

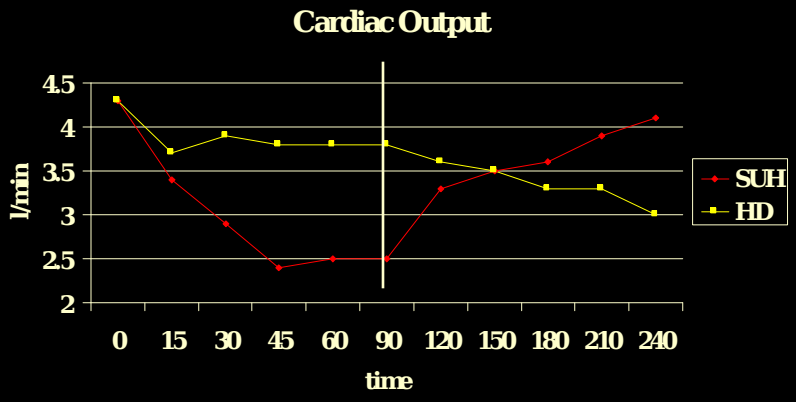

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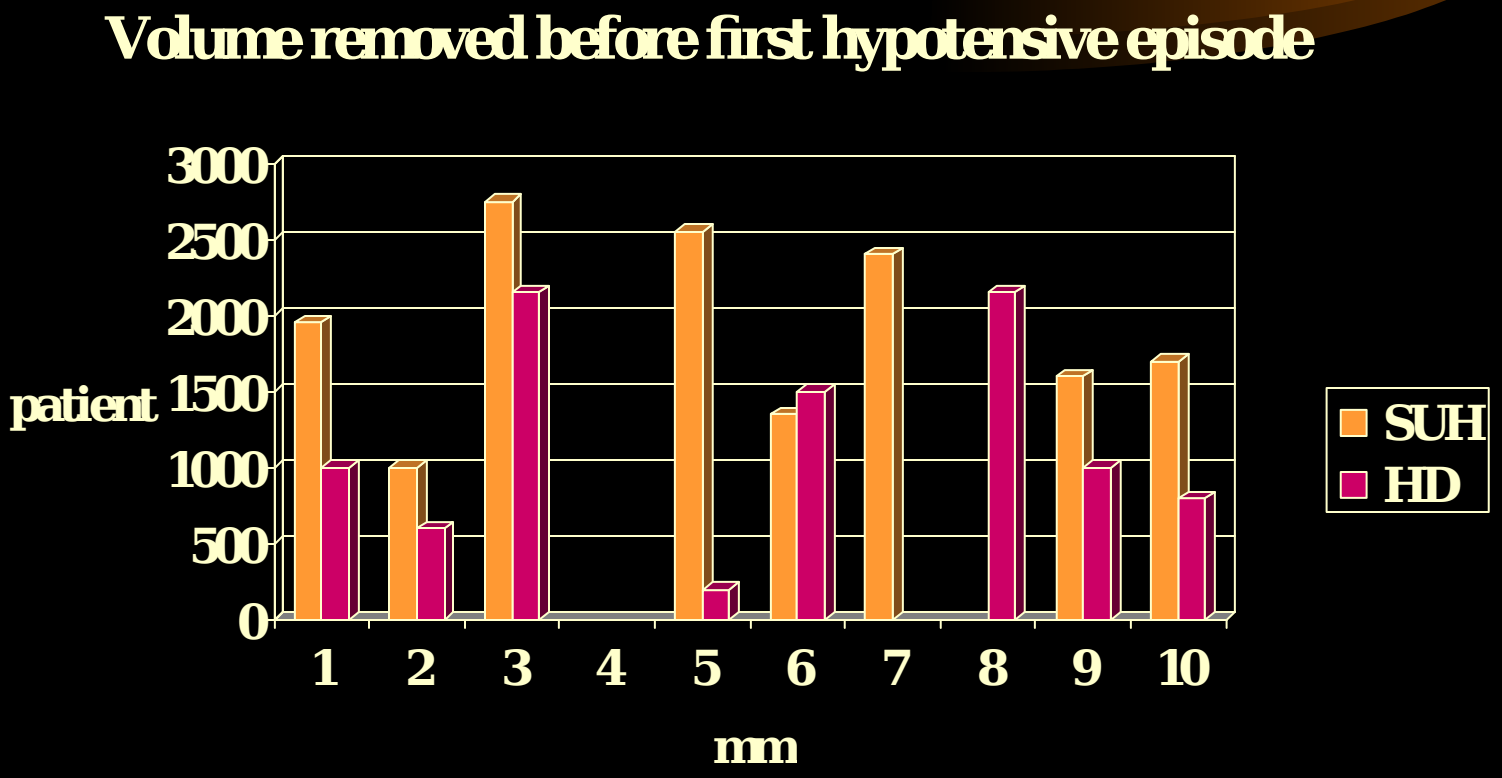

Dialysis associated hypotension

- Cool dialysate
  - well tolerated
  - results in approximately 7mm Hg BP difference
  - best for patients with frequent episodes of hypotension
- Calcium adjustment
  - statistically significant difference, no observed clinical difference

Dialysis associated hypotension

- Sodium modeling
  - well tolerated
  - linear best for cramps
  - step best for post-HD hypotension
- Sequential ultrafiltration
  - allows greater volume removal before first hypotensive episode, but end up at same end point

Cole's Law

Thinnly sliced cabbage